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Delta-9 tetrahydrocannabinol disruption of time perception and of self-timed actions

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Disruption of the ability to judge time is a common effect shared by different classes of drugs with disparate mechanisms of action. This impairment manifests as a change in the subjective awareness of the passing of time, with individuals sometimes experiencing phenomena such as time stopping or changing in speed; and as an alteration in the ability to correctly judge time periods and to generate self-timed actions in a consistent manner [4]. Different mechanisms are hypothesised to underlie the estimation and generation of short (1s or less) time spans (thought to be sub-conscious and dependent upon cerebellar function), and longer periods of time (thought to be governed by thalamo-cortico-striatal circuits) [1]. Here we test the hypothesis that THC disrupts the timing of self-generated actions in healthy volunteers, and that the degree of disruption correlates with self-rated perceptions of time change, attention and concentration.

The study was approved by the Joint Institute of Psychiatry and Maudsley Hospital Ethics Committee. All subjects provided written informed consent. 16 healthy volunteers (9 female, mean(SD) age 26(6) years) were recruited through advertising as part of an ongoing study. All attended for testing twice and were given an intravenous injection of 1.25mg THC on one occasion and placebo on the other in a counterbalanced randomized double-blind manner. At 20 minutes after injection, subjects were asked to press a button at a self-timed rate of approximately one press per second for 70 presses. At 30 minutes post-injection they completed a self-rated questionnaire scoring cannabis-induced effects on 6 questions related to time perception or intoxication (“my perception of time is altered”; “there is an unusual delay between my thinking and speaking”; “I can’t focus my attention”; “I can’t sustain my concentration”; “I feel sleepy” and “I feel drunk”) on a scale from 1-5. We

compared the change in mean press-rate between placebo and THC using a paired t-test. We then investigated whether change in press rate was related to changes in time perception, changes in attention or due to a general effect of intoxication by linear regression of percentage change in tap-time on responses to the six questions, with model simplification by the backward stepwise method. All statistical tests were conducted using the R statistical programming language [2].

THC led to subjective impairment of time perception ($df=15$, $t=3.74$, $p<0.005$), to the experience of an unusual delay between thinking and speaking ($df=15$, $t=3.16$, $p<0.01$; $r=0.79$, $p=0.0003$), as well as to subjective impairment in attention ($df=15$, $t=4.04$, $p<0.005$) and concentration ($df=15$, $t=4.99$, $p<0.0005$). It also induced feelings of drowsiness ($df=15$, $t=3.22$, $p<0.01$) and of feeling drunk ($df=15$, $t=3.92$, $p<0.005$).

THC induced a significant slowing of mean(SD) tap time from 1.49(0.49)s for placebo to 1.73(0.7)s for THC ($df=15$, $t=2.263$, $p<0.05$). Stepwise linear regression revealed that percent slowing of tap time was related to impaired concentration only ($F_{1,14}=6.15$, $p<0.05$), although post-hoc testing revealed a significant relationship with subjective intoxication ($F_{1,14}=5.866$, $p<0.05$) and a trend relationship with the subjective feeling of a delay between thinking and speech ($F_{1,14}=3.73$, $p<0.1$).

There are a number of limitations of this study, most notably the relatively small sample size, and the fact that this analysis (although planned) was performed as part of an ongoing study. The small size increases variability as well as increasing the risk of failing to detect a true positive. Nonetheless, we found a significant effect of THC

on the subjective experience of time passing, as well as a slowing in self-generated tap time. The latter finding is in contrast to a previous study that showed that smoked cannabis increased the rate of counting and tapping in individuals with a history of moderate or heavy cannabis use [4]. It is not clear whether this discrepancy was due to differences in subject group (the volunteers in the present study had considerably lower previous exposure to cannabis), dose (accurate determination of total THC dose is not possible with smoked cannabis, and may have varied between subjects) or route of administration (may have differentially affected the rate of onset of THC-induced effects). Alternatively, the differences may have arisen because THC alone was used in the present study, whereas smoked cannabis also contains a number of other active chemicals, most notably cannabidiol [3].

In the present study, change in tap time was related at trend level only to distortions in time perception, having a stronger association with subjective impairments in concentration and to feelings of intoxication, suggesting that alterations in self-timed tapping may arise through a different mechanism from subjective changes in the experience of the passage of time. It is possible to speculate that feelings of intoxication, and impairments in tap timing arose from effects of THC on subcortical brain regions, whereas subjective experience of time was related to effects on higher brain function. Ongoing work in our laboratory will investigate this possibility.

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